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Before the
Federal Communications Commission
Washington, D.C., 20554

In the Matter of	)	NPRM No. WT 97-12
	)	
Amendment of the Amateur Service	)	
Rules to provide For	)	
Greater Use of Spread	)	
Spectrum Communication Technology	)	

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COMMENTS BY ROBERT J. CARPENTER

Submitted: 4 May 1997

INTRODUCTION

1. I, Robert J. Carpenter, hold amateur radio license W3OTC, and have operated on the amateur VHF and UHF allocations nearly exclusively for more than 50 years. As an electronic engineer, I have been professional involved in digital and packet communication intermittently since 1951. As a radio amateur, I took part in the first 50 MHz amateur meteor burst packet communication.

SUMMARY

2. Spread Spectrum (SS) holds promise to be an interesting and worthwhile addition to the amateur radio community, even in exciting applications apparently not envisioned in the subject Notice of Proposed Rule Making (see paragraphs 16 and 17, below). This said, the assertions of lack of impact of SS on existing users of the amateur bands are incorrect, as I will demonstrate below. Automatic power control will further exacerbate the problem, and represents useless over-regulation. Because of the likelyhood of interference to other amateur operations, and the current lack of *de facto* standardization of amateur SS, it is important that SS stations transmit station identification in a manner that can be clearly understood by non-SS amateurs.

3. The FCC has issued Special Temporary Authority to experiment with SS to various amateurs over a number of decades. To the best of my knowledge, extremely little use has been made of these STAs.

DISCUSSION OF DIRECT SEQUENCE SPREAD SPECTRUM

4. As I pointed out in my Reply Comments on RM-8737, the power density from direct sequence (DS) SS stations can wreak havoc with existing weak signal, EME, and satellite operations over a wide geographical range. I have had a private (and sometimes public, in the vhf@w6yx.stanford.edu Internet group) exchange with Phillip Karn concerning my assumptions and calculations. The most relevant points he asserts are: a) the power output from SS stations will be much less than the 1 W or 100 W I assumed, and b) I should have assumed an attenuation of about the fourth or fifth power of distance, rather than the inverse square law.

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5. A comment on William Tynan's calculations in his Reply Comments on NPRM-8737 (essentially the same as my calculations) has been posted on the Tucson Amateur Packet Radio World Wide Web site. In these comments, Alan Eynon, N3IRL, asserts that the transmitter power Tynan (and I) assumed for SS stations is unrealistically high. He calculates that a DSSS station engaged in communication such as we assumed would require less than 32 microwatts of transmitter power.

6. According to the above-quoted statements by proponents of SS, the FCC's authorization of 100 watts appears grossly excessive. These statements have convinced me that a more approriate power limit would be 1 W for all forms of SS except for the Narrow Band SS discussed in paragraphs 16 and 17, below.

7. The American Radio Relay League (ARRL) and the FCC propose that automatic power control (APC) be required for SS stations using more than one watt. While I disagree with allowing widebande SS stations more than 1 W, I will show here that APC will exacerbate rather than improve the interference situation. Despite questions about the practicality of APC in the amateur radio environment, consider the following. Two DS SS stations (A and B) located 20 kilometers apart are in communication, spreading their 10 kilobit per second data signals over a 500 kilohertz bandwidth. Suppose just one amateur is using 25 W of FM voice (station F), was anywhere within this 500 kHz band, and located 20 km from each of the DS SS stations. Given the processing gain of 50 in this example, the 25 W FM signal will be reduced by the DS SS to the equivalent inference caused by a 0.5 W DS SS station at the same 20 km. But the APC is assumed to increase the power of the SS station to maintain a 23-dB (200:1) power ratio after the SS processing gain. Thus the SS stations would increase their power to 200 times 0.5 W (100 watts), the maximum allowed in the FCC's proposed rules. The 100 W SS stations would transmit a power density of -40 dBW/Hz. At a distance of 20 km, the signal of the DSSS station would be roughly -150 dBW/Hz In the absence of the DSSS signal, the noise floor of a well-equipped weak-signal station would be about -210 dBW/Hz. As seen from this simple example, APC would cause the DSSS stations to increase their power so much that the noise floor seen by *ALL other stations within the 500 kHz spreading band* would be increased by about 60 dB (one million times). It would be impossible for the weak signal stations to increase their power one million fold to overcome the DSSS interference. This example assumes just a single FM station and only one SS contact. Additional stations of either type will exacerbate the problem. The assertions by the ARRL that APC will reduce interference are obviously incorrect, as shown by this straight-forward analysis.

8. As pointed out in (7) above, just a single moderately-strong other-mode station will cause the APC of SS stations to greatly increase their power and interfere with all other-mode stations anywhere within their spreading spectrum, no matter how weak the additional users. This calculation justifies use of higher powers in the data I presented on RM-8737, which showed an increase of 50 dB (100,000:1 power ratio) in the background noise which weak signal stations would have to overcome. It is ludicrous to contemplate weak signal stations increasing their power by 100,000 times in order to be able to continue to communicate as they do today. I conclude that the requirement for APC constitutes over-regulation and will also be useless.

9. For purpose of discussion, assume that Kam is correct and that one must assume a fourth-power vs. distance attenuation between "typically" sited SS stations. But weak signal and FM repeater stations go to great lengths to obtain optimum locations. These sites often have line-of-sight paths over large areas, and their attenuation vs. distance will, in fact, be closer to my assumed inverse square law. Thus we have the unfortunate situation where the attenuation between to two SS stations desiring to

communicate is much greater than to the stations they are causing interference to.

10. The above discussions illustrate that DS SS stations and stations using other modes make bad neighbors. In light of this, how can the FCC assert that SS will increase spectrum efficiency?

11. The FCC mentions in paragraph 8 of the Notice, amateur tests purport to show no impact by SS on other amateur operation. As I understand what happened, the tests were of short duration, and requests by other amateurs for the details of the tests have been to no avail. I conclude that there has been **no** credible field testing to validate the assumption that band sharing is possible. The FCC, in paragraph 7 of the Notice, quotes the ARRL as saying that interference from SS would not increase since it has been authorized for more than a decade. Yes, it has been authorized. No, essentially no one has used the authorization. This is a disingenuous argument. Since the FCC allowed operation under the "TAPR" STA without identification that could be understood by non-participants, and with no prior or post notification of the amateur community sharing the bands, it is hardly surprising that no interference from these tests has been reported.

DISCUSSION OF FREQUENCY HOPPING SPREAD SPECTRUM

12. In the alternative common type of SS, frequency hopping (FH) SS, the transmitter is modulated in a conventional manner, but hops between a substantial number of frequencies so as to interfere with each (and suffer interference on each) a small portion of the time. In realistic systems of this type, the bandwidth occupied and the power density on each of the frequencies is related to the conventional modulation used, not the hopping rate. It is asserted that the result for other users will be just an occasional "tick" as the FHSS station occupies "their" channel. Even if this were true for interference from a single FHSS station, the ticks would become a roar when a number of FHSS stations were present.

13. During the dwell time on the non-SS station's frequency, the full power of the FHSS would be transmitted on the channel. The comparison must be made between the signal received from the FHSS station and the distant weak signal the other-mode station is in communication with. If the weak-signal station's noise floor is -210 dBW, and the FHSS transmits only one watt from a location 20 kilometers from the weak signal station, the FHSS station's signal will be roughly 110 dB below one watt at the weak-signal station's location. This is 100 dB (ten billion times) louder than the weak signal station's noise floor. Of course the single FHSS station's signal may only be on-channel for one percent of the time. However, sensative radio receivers take a *LONG* time to recover from a ten billion times signal overload. The FHSS station would probably have completed its sequence and hop back to the other-mode station's frequency before the receiver recovered. The popular term is that the receiver "dies".

14. It has been proposed that FHSS stations choose to transmit in the "guard bands" halfway between the channels used by FM repeater outputs. Since FM repeater guard bands are already smaller than the bandwidth occupied by typical high speed data transmissions, the FHSS signal between repeater channels would interfere with the repeaters on both sides of it.

15 The above indicates that FHSS cannot share band segments with existing modes.

NARROW BAND SPREAD SPECTRUM

16. All of the previous discussion of DSSS has assumed high data rates and wide bandwidths, and its

use for very local communication. Thomas A. Clark and Phillip Karn presented a very interesting unpublished paper at the 1996 Conference of the Central States VHF Society. They proposed that techniques which are essentially DSSS be used for extremely weak signal amateur operations such as communication by reflection off the Moon. Their proposal envisions a maximum data rate of a few bits per second, spreading over only a few kilohertz, and use of the usual maximum amateur power in the vicinity of one kilowatt output. It would be a mistake for the FCC to adopt Rules which prevent this type of advanced operation.

17. How can the above exciting use of DSSS be accommodated in the Rules, without the disastrous consequences that wideband DSSS would cause if allowed in the weak-signal band segments? The obvious solution is to define Narrow Band Spread Spectrum (NBSS). The FCC has a long history of allowing new modes *if they occupy no more bandwidth than the existing modes used in that band-segment.* I understand that William Tynan will propose a similar class of NBSS. The bandwidth allowed (or commonly used) in VHF and UHF weak signal voice and MCW subbands is no more than 10 kilohertz. I propose that the bandwidth of NBSS be limited to 10 kHz. In order to be useful, the power limit for NBSS must be the same as for the other narrow band weak signal and FM users, not the 100 watts proposed by the FCC for wideband SS.

18. Since NBSS uses approximately the same spectrum width as the more traditional modes such at narrow FM, MCW, etc., I feel that it should be authorized on all amateur frequencies above 50 MHz where MCW is authorized.

INTERFERENCE FROM AND TO TERTIARY NONAMATEURS SHARING 902 MHz

19. The FCC notes in Paragraph 6 of the subject NPRM, that commercial interests providing an unlicensed service in the 902 -928 MHz band are concerned about interference from amateur SS stations. While the amateur operation is secondary on this band, the unlicensed devices are tertiary users. It is unreasonable to expect licensed users to modify their operation to accommodate unlicensed users who knew full-well that they would have to accept any and all interference.

20. A far worse situation is that, contrary to the terms of the Rules, the unlicensed users of 902-928 MHZ are creating a great deal of interference to the licensed amateur users of this band. An example is the Houston area, where Ronald Marosko, K5LLL, tells me that the noise floor has increased at least 30 dB (one thousand times power ratio) since unlicensed users have become active on the band.

RECOMMENDED MODIFICATIONS TO PART 97 OF THE RULES

I recommend that Part 97 of the Rules be modified as shown below. **As a basis, I am using the changes proposed by the FCC in the subject NPRM.** My additions are shown in ***bold italics***. Deletions are enclosed in [brackets].

No change to the identification requirements of §97.119 (b) (5).

§ 97.305 Authorized Emission Types

(a) - (c) Unchanged

(d) SS emission transmissions which occupy a total bandwidth of no more than 10 kHz may use any amateur frequency above 50 MHz where MCW emission is authorized.

§ 97.311 SS emission types.

(a) SS emission transmissions by an amateur station are authorized only for communications between points within areas where the amateur service is regulated by the FCC and between an area where the amateur service is regulated by the FCC and an amateur station in another country that permits such communications. SS emission transmissions must not be used for the purpose of obscuring the meaning of any communication.

(b) A station transmitting SS emissions must not cause harmful interference to stations employing other authorized emissions, and must accept all interference caused by stations employing other authorized emissions.

(c) Reserved.

(d) Reserved.

(e) *****

(f) *****

(g) The transmitter power must not exceed ***1 W if the SS emission occupies a bandwidth of greater than 10 kHz.***

The following to be removed:
[100 W under any circumstances. If more than 1 W is used, automatic transmitter control shall limit output power to that which is required for the communication. This shall be determined by the use of the ratio, measured at the receiver, of the received energy per user data bit (Eb) to the sum of the received power spectral densities of noise (N_0) and co-channel interference (I_0). Average transmitter power over 1 W shall be automatically adjusted to maintain an Eb/ ($N_0 + I_0$) ratio of no more than 23 dB at the intended receiver .]

Respectfully submitted,

Robert J. Carpenter